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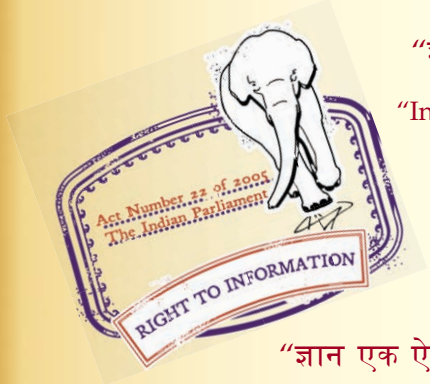

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"Knowledge is such a treasure which cannot be stolen"

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IS : 11530 - 1985
(Reaffirmed 2001)

Indian Standard

SPECIFICATION FOR VOLTAGE GRADING CAPACITOR

UDC 621·319·4 : 621·316·57·064·31

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4

November 1986

Indian Standard

SPECIFICATION FOR VOLTAGE GRADING CAPACITOR

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Indian Standard

SPECIFICATION FOR VOLTAGE GRADING CAPACITOR

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 26 November 1985, after the draft finalized by the Power Capacitors Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The voltage grading capacitors are used for extra high voltage multi-break circuit-breakers They ensure an equal voltage stress across all the breakers of a pole of a circuit-breaker with multiple interruption in the open state as well as during the switching process.

0.3 The voltage grading capacitors have special design feature. The dielectric consists of high density capacitor grade tissue paper impregnated with mineral oil and is housed in porcelain. The impregnated oil is specially treated and subjected to very fine degree of filtering and to very high vacuum.

0.4 The voltage grading capacitors are manufactured in porcelain housing with aluminium flange and cover plates to minimize weight.

0.5 While preparing this standard assistance has been derived from IS : 9348 - 1979*.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2 - 1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies the requirements of porcelain housed capacitors (up to 250 kV rating) used for extra high voltage (EHV) multi-break circuit-breakers.

*Specification for coupling capacitor and capacitor divider.

†Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.0 For the purpose of this standard, definitions given in IS : 1885 (Part 42) - 1977*, in addition to the following, shall apply.

2.1 Type Tests — Tests carried out to prove conformity to this specification. These are intended to prove the general qualities and design of a given type of capacitor.

2.2 Acceptance Tests — Tests carried out on samples selected from a lot for the purpose of varifying the acceptability of the lot.

2.2.1 *Lot* — All capacitors of the same type, design and rating, manufactured by the same factory during the same period, using the same process and materials, offered for inspection at a time shall constitute a lot.

2.3 Routine Tests — Tests carried out by the manufacturer on each capacitor to check requirements which are likely to vary during production.

3. RATINGS

3.1 Voltage — The preferred rated voltage of capacitors shall be 36,52 72·5,145 and 245 kV (highest system voltage) in accordance with values specified in IS : 585 - 1962†. The maximum operating system voltage shall not exceed these values by more than 10 percent.

3.2 Capacitance — The rating of capacitance shall be specified in pico-Farad. The rated value of the capacitance shall be declared by the manufacturer from a range of 500 pF to 2 500 pF. The value of capacitance shall fall within a tolerance of $\begin{matrix} -\ 5 \\ +\ 10 \end{matrix}$ percent of the rated value.

3.3 Frequency — The frequency for the purpose of this standard shall be 50Hz

NOTE — If a frequency higher or lower that than specified above is specified by the purchaser, it does not preclude from this standard. In such a case corresponding changes, where necessary, shall be taken into account.

4. SERVICE CONDITIONS

4.1 Ambient Temperature — Capacitors shall be suitable for operation in any of the temperature categories given in Table 1. The temperature category of capacitors shall be specified by the purchaser.

*Electrotechnical vocabulary : Part 42 Power capacitors.

†Specification for voltages and frequency for ac transmission and distribution systems (*revised*).

NOTE — If the capacitors are likely to be subjected to temperature of −10°C or below in their unenergized state, this shall be indicated at the time of placing the order.

TABLE 1 AMBIENT TEMPERATURE

(*Clause* 4.1)

Upper Limit of Temperature Category	Maximum Ambient Temperature		
	Mean Over 1 Hour	Mean Over 24 Hour	Mean Over 1 Year
(1)	(2)	(3)	(4)
°C	°C	°C	°C
40	40	30	20
45	45	35	30
50	50	45	35

4.2 Altitude — Unless otherwise specified, capacitors shall be suitable for operation on sites at altitudes up to and including 1 000 metres above sea level.

4.3 Mounting — The capacitors covered by this standard are suitable for mounting in any inclined position as well.

5. INSULATION LEVELS

5.1 The insulation level is defined by the rms value of the power frequency test voltage and the peak value of the impulse test voltage. The standard values of insulation levels with corresponding highest system voltages *Um* are specified in Table 2.

TABLE 2 INSULATION LEVELS

(*Clause* 5.1)

Highest System Voltage (Line-to-Line)	Insulation Levels	
	Power Frequency Test Voltage	Impulse Test Voltage
Um		
(1)	(2)	(3)
kV rms	kV rms	kV Peak
36	*	*
52	195	400
72·5	245	555
145	*	*
245	*	*

*The values shall be decided in consultation with switchgear manufacturer (purchaser).

6. MARKING

6.1 The following information shall be marked on each capacitor unit:

a) Manufacturer's name or trade-mark, if any;
b) Identification number;
c) Rated capacitance in pF;
d) Rated voltage in kV;
e) Rated frequency in Hz;
f) Temperature category (*see* **4.1**); and
g) Insulation level (*see* Note).

NOTE — Insulation level shall be written by means of two numbers, separated by a stroke. First number would represent the rms value of the power frequency test voltage in kV, and second the crest value of the impulse test voltage in kV peak.

6.1.1 The capacitor may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act, and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions, under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

7. TESTS

7.0 Standard Temperature for Tests — The standard ambient temperature range for testing is from 15 to 35°C.

7.1 Classification

7.1.1 *Type Tests* — The following shall constitue type tests:

a) Capcitance measurement before voltage test (**7.2**),
b) Voltage test between terminals (**7.3**),
c) Measurement of capacitance and tangent of the loss angle after voltage test (**7.4**),
d) Oil leakage test (**7.5**),
e) ac voltage test (dry) (**7.6**).
f) ac voltage test (wet) (**7.7**),

g) Impulse test (7.8),

h) Partial discharge test (7.9), and

j) Determination of temperature co-efficient (7.10).

NOTE — The test (j) shall be subjected to an agreement between the manufacturer and the purchaser.

7.1.1.1 *Criteria for approval* — One sample shall be submitted for testing together with the relevant date. The testing authority shall issue a type approval certificate if the capacitor is found to comply with the requirement of tests listed in 7.1.1.

7.1.1.2 In case of failure the testing authority may call for a maximum of two samples and subject them to the test(s) in which failure occurred. If in repeated test(s) no failure occurs, the type shall be considered to have met the requirements of this standard.

7.1.2 *Acceptance Test* — The following shall constitute the acceptance test:

a) Capacitance measurement before voltage test (7.2),

b) Voltage test between terminals (7.3),

c) Measurement of capacitance and tangent of the loss angle after voltage test (7.4), and

d) Oil leakage test (7.5).

7.1.2.1 *Sampling procedure and criteria for acceptance of a lot* — The recommended plan of sampling for acceptance tests is given in Appendix A.

7.1.3 *Routine Tests* — The following shall constitute the routine tests:

a) Capacitance measurement before voltage test (7.2),

b) Voltage test between terminals (7.3),

c) Measurement of capacitance and tangent of the loss angle (tan δ) after voltage test (7.4), and

d) Oil leakage test (7.5).

7.2 Capacitance Measurement of Power Frequency

7.2.1 *Measurement of Capacitance Before Voltage Test* — This test is carried out on the voltage grading capacitor unit. The capacitance shall be measured using a method that excludes errors due to harmonies and to accessories in the measuring circuit.

The final capacitance measurement shall be carried out at 0·9 to 1·1 times the rated voltage/ after the voltage tests (*see* 7.3). In order to reveal any change in capacitance due to the puncture of one or more elements, a preliminary capacitance measurement shall be made, before the voltage routine tests, at a sufficiently low voltage (less than 15 percent of rated voltage) to ensure that no puncture of an element will occur.

An additional measurement at 0·9 to 1·1 times the rated voltage is also made before the voltage tests (*see* 7.3).

NOTE 1 — If the number of the elements in series in the tested unit is large, it may be difficult to ascertain that no puncture had occurred because of the following uncertainties:

a) Reproducibility of measurement,
b) Capacitance change caused by the mechanical forces on the elements during the voltage tests, and
c) Capacitance change caused by temperature difference of the capacitor before and after the tests.

In this case it should be proved by the manufacturer, for example, by comparison between the capacitance variations of capacitors of the same type and/or by calculation of the capacitance change caused by the temperature increase during the test that no puncture had occurred. In view of the uncertainty in the case where measurements are made on a stack, it may be perferable to carry out those measurements on each unit separately.

NOTE 2 — Measurement of the capacitance may be made at a frequency outside the range specified in 3.3, provided an appropriate correction factor is agreed upon.

7.2.1.1 *Capacitance tolerance* — The measured capacitance shall not differ from the rated capacitance by more than $+\frac{10}{-5}$ percent. The change in capacitance measurements shall not differ by either 2 percent or that caused by the puncture of an element whichever is lower. The data regarding the variation due to puncture of an element shall be furnished by the manufacturer.

7.3 Voltage Test

7.3.1 *Routine Test* — Every capacitor is tested by applying voltage across the unit. During the test neither puncture nor flashover shall occur.

The test shall be carried out with a substantially sinusoidal waveshape in accordance with IS : 2071 (Part 2) - 1974*. The voltage shall

*Methods of high voltage testing : Part 2 Test procedures (*first revision*).

be rapidly increased from a relatively low value to the test voltage value maintained for 1 minute. The value for the test voltage shall be as agreed to between the manufacturer and the purchaser.

7.3.2 *Type Test* — ac voltage test, dry (for indoor capacitors) — The test shall be carried out on the capacitor stack. An ac test voltage equal to the rated short duration power frequency withstand voltage given in Table 2 and corresponding to the highest voltage for the equipment of the capacitor shall be applied between the high voltage and earth terminals. When a low voltage terminal is provided it shall be connected directly or through a low impedance to the earth during this test.

The test shall be carried out with substantially sinusoidal waveshape in accordance with IS : 2071 (Part 2)-1974*. The voltage shall be rapidly increased from a relatively low value to the test voltage value maintained for 1 minute and rapidly reduced to a relatively low value before being switched off.

No flashover or puncture shall occur. To ensure that no puncture has occurred a measurement of the capacitance of the unit at 0·9 to 1·1 times the rated voltage shall be made before and after the test (*see also* Note 1 to **7.2.1**).

7.3.2.1 *AC voltage test, wet (for outdoor capacitors)* — The test conditions are same as specified in **7.3.2** but under artificial rain in accordance with IS : 2071 (Part 1)-1974†.

7.4 Measurement of Capacitance and Tangent of the Loss Angle (tan δ) After Voltage Test

7.4.1 The capacitance and tangent of the loss angle shall be measured at rated frequency and rated voltage and using the same method, and at a temperature as close as possible to that for **7.2.**

7.4.2 *Requirements*

7.4.2.1 The measured capacitance shall not differ from the rated value by more than −5 percent or +10 percent. The ratio of the capacitances of any two units forming part of a capacitor stack shall not differ by more than 5 percent from the reciprocal ratio of the rated voltages of the units. Any difference from the values measured before the voltage tests (*see* **7.2**) shall not be such as would indicate breakdown of one or more elements.

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*Methods of high voltage testing : Part 2 Test procedures (*first revision*).

†Methods of high voltage testing : Part 1 General definitions and test requirements (*first revision*).

7.4.2.2 The value of the tangent of the dielectric loss angle determined by test, shall not exceed by more than 10 percent of the value agreed to between the manufacturer and the purchaser.

NOTE 1 — The purpose of the measurement of tan δ is to check the uniformity of the production.

NOTE 2 — Change in capacitance may also occur by mechanical forces on the elements during the voltage test in this case, it should be proved by manufacturer that the capacitance change is not caused by a breakdown.

7.5 Oil Leakage Test (or Sealing Test) — The enclosure of the capacitor shall be tested by a method to be agreed between the manufacturer and the purchaser. The test may be performed at any time after the sealing of the enclosure.

7.6 ac Voltage Test (Dry)

7.6.1 This test shall be applicable to indoor type capacitors and need only be carried out if the, routine test according to **7.3** has been carried out with dc voltage.

7.6.2 *Requirement* — No flashover or puncture shall occur.

7.7 ac Voltage Test (Wet) — (Applicable to outdoor type capacitors)

7.7.1 The test shall be carried out on an outdoor type complete capacitor stack under artificial rain conditions.

7.7.2 *Requirement* — The capacitor shall withstand ac voltage test specified under **7.3**.

7.8 Impulse Test

7.8.1 The capacitor unit shall be subjected to an impulse test applied between the terminals.

7.8.2 The crest value shall correspond to the insulation level of the capacitor (*see* **7.5**). The waveform of the applied impulse shall be the standard wave but the front time may be increased to a maximum of 5 μs. Five impulses of each polarity shall be applied.

7.8.3 *Requirement* — If more than one flashover occurs, the capacitor shall be deemed as not having passed the test. If one flashover occurs in a series of five impulses of the same polarity, ten additional impulses of the same polarity shall be applied and there shall be no further flashover in any of these impulses.

7.9 Partial Discharge Test

7.9.1 This test shall be carried out on a separate capacitor unit.

7.9.2 A sinusoidal test voltage shall be applied at or around the rated frequency of the capacitor. The test circuit shall be suitably damped to reduce overvoltage due to transients. Ambient temperature shall be maintained to standard range during testing.

7.9.3 A test voltage equal to 75 percent of the 1 min ac test voltage shall be applied only once to the capacitor for 1 s. The voltage shall then be reduced to 45 percent of the 1 min ac test voltage and maintained for a period of 10 min, after which the voltage shall be raised to 55 percent of the 1 min ac test voltage and maintained for a period of 10 min.

7.9.4 *Requirements* — At no time during this 10 min period should an increase in the magnitude of the partial discharges be observed. Any standard method capable of detecting a discharge of 10 pC, occurring once every half cycle may be adopted. Capacitance shall be measured before and after the test under indentical conditions. The capacitance shall not change by more than ±5 percent. The corrections given **7.2.1** (Note 1) shall also apply. The reproducibility of the measurement and the fact that an internal change in the dielectric may cause a small change of capacitance without breakdown of any element of the capacitor shall be taken into account while interpreting the results of these measurements.

NOTE 1 — During the above test cycle there should be no interruption of the test voltage otherwise the test shall have to be started afresh.

NOTE 2 — If the capacitance of the unit is larger than the capacity of test apparatus then the measurement of the magnitude of partial discharge may be insensitive.

In such cases, tests may be carried out on a model unit of a lower voltage and/or capacitor rating but of identical design and construction as that being supplied.

NOTE 3 — The test circuit shall be such that the measurement of partial discharge intensity is not effected by corona discharges.

7.10 Determination of Temperature Co-efficient

7.10.1 This test applies to capacitor unit and need only be carried out if agreed to between the purchaser and the manufacturer.

7.10.2 The test should be carried out on a capacitor unit. The test capacitor shall be placed in an enclosure in which the air temperature can be adjusted to any value between the lower limit of the temperature category and 15°C in excess of the upper limit of the temperature category.

7.10.3 Alternatively, an oil bath which can be adjusted within the same temperature limits may be used. The value of the capacitance

(and, for information, the tangent of the loss angle) shall be measured at reduced voltage (but not less than 0·25 *Un*) and rated frequency at temperature intervals of approximately 15°C. Before each measurement thermal equilibrium of the capacitor shall be established.

7.10.4 The test voltage shall only be applied to the capacitor for the period of time necessary for taking the measurement.

NOTE 1 — If a model capacitor is used for this test, the number of elements employed shall be sufficiently large to ensure that together with their clamping devices they constitute a model which is truly representative, both mechanically and electrically, of the capacitor under consideration.

NOTE 2 — If the manufacturer can provide a test certificate of an earlier test covering the entire temperature range mentioned in this clause, a repetition of the test over smaller temperature range may be agreed upon.

7.10.5 *Requirement* — The temperature coefficient derived from these measurements shall not exceed either the value specified by the purchaser or in the absence of a specified value, the value guaranteed by the manufacturer.

8. GUIDELINES FOR INSTALLATION AND OPERATION

8.1 The guidance for proper installation and operation of the voltage grading capacitor is given in Appendix B.

APPENDIX A

(*Clause* 7.1.2.1)

SAMPLING PLAN FOR VOLTAGE GRADING CAPACITORS

A-1. SCALE OF SAMPLING

A-1.1 Lot — All the capacitors of the same rating manufactured from the same material under similar conditions of production shall be grouped together to constitute a lot.

A-1.2 The number of the capacitors to be selected from each lot shall depend upon the size of the lot and shall be in accordance with col 1 and 2 of Table 3.

A-1.2.1 These capacitors shall be selected from the lot at random. In order to ensure the randomness of selection, procedure given in IS : 4905-1968* may be followed.

*Methods for random sampling.

TABLE 3 SAMPLE SIZE AND PERMISSIBLE NUMBER OF DEFECTIVES

(*Clauses* A-1.2 *and* A-2.1)

LOT SIZE	SAMPLE SIZE	PERMISSIBLE NO. OF DEFECTIVES
(1)	(2)	(3)
Up to 50	5	0
51 ,, 100	8	0
101 ,, 300	13	1
301 , 500	20	1
501 ,, 1 000	32	2
1 000 and above	50	3

A-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

A-2.1 The capacitors selected at random according to col 1 and 2 of Table 3 shall be subjected to each of the acceptance tests. A capacitor failing to satisfy the requirements of any of these tests shall be termed as defective. The lot shall be considered conforming to these requirements if the number of defectives found in the sample is less than or equal to the corresponding permissible number given in col 3 of Table 3; otherwise the lot shall be rejected.

APPENDIX B

(*Clause* 8.1)

GUIDELINES FOR INSTALLATION AND OPERATION OF THE VOLTAGE GRADING CAPACITORS

B-1. CHOICE OF RATED VOLTAGE

B-1.1 The rated voltage U_n and maximum voltage U_n of the voltage grading capacitor depends on the design of the circuit-breakers.

B-2. CHOICE OF INSULATION LEVEL

B-2.1 The choice of the insulation level may be agreed to between the manufacturer and the user.

B-3. CHOICE OF THE TEMPERATURE CATEGORY

B-3.1 The lower limit of the temperature category should obviously be chosen in accordance with the lowest ambient air temperature expected at the proposed location of the capacitor.

B-3.2 Capacitors in outdoor positions, unprotected from sun, and composed of units with dark coloured housings should have higher upper temperature li mit.

B-4. LENGTH OF LEAKAGE PATH

B-4.1 The length of the leakage path of the insulators shall be designed to meet the insulation requirements at the site of erection with special regard to the possible atmospheric pollution. It is found that requirements of insulation and atmospheric pollution are met when the length of leakage path is 23/1·5 mm per kV of the highest system voltage in clean areas and 23 mm per kV in normally polluted atmospheres. For heavily polluted atmospheres sufficient measures should be taken.

B-5. MECHANICAL STRESS

B-5.1 Capacitor stacks for use on outdoor mountings should adequately be designed to withstand any mechanical stresses which may result due to wind pressure, ice formation or earth tremors. Connections of capacitor stacks should be such that no lateral pull is experienced by capacitors.